W72-12922

EPA-R2-72-050
August 1972

PB 211 448

FULL SCALE CONVERSION OF ANAEROBIC DIGESTERS TO HEATED AEROBIC DIGESTERS

by

CITY OF HAMILTON, OHIO
WASTE WATER TREATMENT PLANT
2451 RIVER ROAD
HAMILTON, OHIO 45011

for the

WATER QUALITY OFFICE

ENVIRONMENTAL PROTECTION AGENCY

PROJECT #17070 DIW

JUNE, 1971

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SELECTED WATER RESOURCES ABSTRACTS
INPUT TRANSACTION FORM

1. Report No. | 2. | W 72-12922

4. Title: FULL SCALE CONVERSION OF ANAEROBIC DIGESTERS TO HEATED AEROBIC DIGESTERS

5. Report Date ~~June 1972~~
6.
8. Performing Organization Report No.

Author(s)

Organization: City of Hamilton, Ohio
Waste Water Treatment Plant

10. Project No. EPA Program
✓ 17070 DIW

11. Contract/Grant No.
WPRD 187-01-68

13. Type of Report and Period Covered ~~Final Rpt. June 1, 1960-June 30, 1970~~

12. Sponsoring Organization ~~Environmental Protection Agency~~

Environmental Protection Agency Report No. EPA-R2-72-050 - (August 1972), June 1972,
56p, 5 fig, 3 tab, 4 ref, 3 append.

Full plant scale experiments were made to determine the effect of heated aerobic digesters on digestion of waste water treatment plant sludge. Existing heated, floating cover equipped, anaerobic digesters, which had failed under excessive paper mill waste discharge, were converted to this purpose by addition of blower supplied air. The program contemplated phase experiments over a wide range of varying time, loading, air rate, and temperature conditions.

Excessive odor production as temperatures increased prevented conclusion of the total program or any single phase. No practical method for control of temperature resultant from bacterial energy exerted in volatile reduction could be devised.

The experiment was beneficial in determing the extent of practical application, and in establishing that thermophilic digestion temperature ranges could have produced significant volatile reduction. Determinations made also afford a measure of energy (heat) generated by aerobic bacteria in destruction of waste.

Cost analysis is not available from limited scope (excepting conversion contract price), but initial installation appears unattractive. Conversion of existing facilities, however, could reflect savings. (EPA abstract)

17a. Descriptors
~~Digestion~~ *Waste water treatment, *Anaerobic digestion, *Odor, Pilot plant, Sludge treatment, *Ohio, *Aerobic treatment, *Sludge digestion, *Heat treatment

17b. Identifiers
~~Heated aerobic~~, *thermophilic digestion, nuisance odor, *Hamilton (Ohio)

PB-211 448
05D

Available from the National Technical Information Service as PB , $3.00 in paper copy, ~~$0.95~~ in microfiche

18. Availability: ~~Limited number of copies at City of Hamilton Waste Water Treatment Plant~~
19. Security Class. (Report)
20. Security Class. (Page)
21. No. of Pages ~~65~~
22. Price

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SECTION I

CONCLUSIONS

1. Due to odor nuiscance at uncontrollable temperatures produced by bacterial energy, experiments could not be carried to completion, but were sufficiently extensive to establish that volatile reduction does occur.

2. Had conditions allowed it is probable that temperatures in thermophilic ranges could accomplish significant reduction. Had the covers been removed it is probable that operation could have been continued, but only as conventional aerobic digesters at normal waste temperatures.

3. Analysis of recorded conditions provides factual basis for evaluation of energy released by bacterial action in aerobic reduction of waste. Control of heat thus produced was found to be not reasonably possible.

4. Inconclusive results do not allow reasonable cost analysis, but would not be attractive for initial installation. If successful results without nuisance could be produced, conversion of existing facilities might be economically feasible.

SECTION II

RECOMMENDATIONS

The experiments were conducted on full plant scale of a normally operating activated sludge plant. While the full scope of the program could not be completed, due to inability to control temperature and resultant offensive odor nuisance, it can be negatively concluded from these very facts that the process does not appear practically feasible, and its consideration for use in other instances cannot be recommended without qualification. Should such consideration be given it is strongly recommended that exhaustive pilot plant experimentation precede a final decision.

The unexpected development of criteria to determine bacterial energy released in the aerobic reduction process, is of considerable interest. Some further study of this phase, where convenient to other experimental programs, might be tentatively recommended.

SECTION III

INTRODUCTION

The City of Hamilton, Ohio has conducted a study on the effects of heating covered aerobic digesters. The program was instituted in an effort to reduce the sludge volume to dewatering facilities, following repeated failures of anaerobic digester due to excessive waste discharged from the paper manufacturing industry. A long period of carefully controlled operational procedures conclusively demonstrated that a successful and uninterrupted anaerobic process could not be established under these waste conditions. A combination of previous commitments, and various other considerations, prevented elimination of the troublesome waste from the sewerage system, at least without somewhat drastic action which the City did not desire to institue. There was no convenient way to remove the papermill waste for separate treatment, inasmuch as it enters the collection system at remote locations.

A reasonably thorough search of the pertinent literature, revealed comparatively little on plant scale application of aerobic digestion to wastes encompassing both municipal (domestic) and those produced by the manufacture of paper. Data available did, however, reasonably establish the feasibility of such an application. Carpenter and Blosser (1), summarizing experiments conducted by The National Council For Stream Improvements on Ohio papermill wastes, reported (1) that aerobic digestion of produced sludges was effective, provided nutrient levels were maintained, and (2) that a 10 degree C rise in temperature markedly increased volatile reduction. Dreier (2), reporting on experiments on aerobic digestion conducted by the University of Wisconsin under auspices of Walker Process Equipment Company, states that, in general, a higher reduction in volatile solids is obtained at higher digestion temperatures. Kambhu and Andrews (3) in their paper on Thermophilic aerobic digestion, presented at the 41st Annual Water Pollution Control Federation Conference (Chicago 1968), concluded that the process increases volatile reduction, and that it is self sustaining in temperature, provided there is adequate enclosure and insulation of the container.

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It is noted that the above referenced experimental works were largely limited to bench or very small pilot scale. It did, however, establish the feasibility of undertaking demonstration measures for the contemplated process on a full plant scale. In accordance with this the City of Hamilton made application to The Federal Water Pollution Control Administration for a Research and Development Grant as provided under the Clean Water Restoration Act of 1966. It is noted that the name of the Federal Water Pollution Control Administration (FWPCA) was changed to the Federal Water Quality Administration (FWQA) during the course of this project, and that most of the program was carried out under the auspices of the FWQA. Subsequently, but not until the project was completed, the name was again changed to the Environmental Protection Agency (EPA), Water Quality Office (WQO), under which present name this report is issued. The final application, after revision in various phases as developed in conferences in Washington, D. C. and Cincinnati, Ohio offices of FWQA, was submitted in May, 1968. The Grant offer was received on June 28, 1968, and City of Hamilton acceptance was dated August 9, 1968. The total estimated project cost was $322,406.00 and the FWQA Grant was for $247,804.00 or 75% of the total eligible cost, whichever was less. The period of the project was established at two (2) years.

SECTION IV

OBJECTIVES OF PROGRAM

The primary purpose of this grant program was to determine, under full plant scale operation, the effect of heat application to the aerobic digestion process in the reduction of volatiles in combined primary and waste activated sludges; and to further determine the practical value, as well as theoretical aspects, of such an application. Specific objectives outlined in the application and approved grant were:

1. Determine if sludge age (residence time) is a criteria in obtaining efficiency of volatile solids removal.

2. Determine if a more rapid reduction in volatile solids is obtainable at higher temperatures in aerobic digestion.

3. Determine if digested sludge from the aerobic process will drain and dry readily without objectionable odors.

4. Determine the velocity of solids movement in the digester to prevent undesirable settling and to effect increased oxygenation.

5. Determine the effect of aerobic digestion, if any, on nutrient (phosphorous and nitrogen) removal.

6. Determine and classify biological life present under various phases of the operating procedures. (This phase to be performed by Robert A. Taft Sanitary Engineering Center, FWQA, Cincinnati, Ohio, on samples transported from the plant.)

These objectives obviously were not all predicated solely on the heating factor, but also extended to the more conventional practices of the aerobic digestion process. It was believed that all phases contributory to general knowledge of this relatively recent process were worth exploring. Substantiation or, if necessary, revision of parameters and criteria developed in previously reported studies, was considered of almost equal importance to the principal objective. Comprehensive coverage of previous developments is given in a paper on design factors, presented by Loehr (4) at the 1965 Great Plains Sewage Works Conference.

Preliminary Considerations

Intensive study was given to the various specific and detailed requirements for accomplishment of the ultimate experimental program. These included (1) the existing plant facilities, (2) the conversion of existing anaerobic digesters to process requirements, and (3) the establishment of detailed testing procedures.

SECTION V

EXISTING PLANT DESCRIPTION

The Hamilton Waste Treatment Plant was constructed in 1958 and placed in full operation early in 1959. The plant, employing the split treatment method, is designed to provide primary treatment for 12.0 MGD and complete secondary treatment, by means of the activated sludge process, for 6.0 MGD. The effluent requirements to the Great Miami River at the time of design were comparatively low (66% removal of BOD and 75% of suspended solids), necessitating only intermediate treatment as reflected in the split treatment design. The plant incorporated heated anaerobic sludge digestion, and vacuum filtration of waste digested sludge. Waste activated sludge is returned to the plant influent and is removed in the primary settling tanks in combination with the raw primary sludge. Digested sludge disposal (filter cake) is to land fill on the plant site. Figure 1, Plant Flow Diagram, shows the general arrangement of the plant. Flow metering is as shown on the Diagram. Sewage lift pumps and air blowers are driven by gas engines, providing a readily available heat source. Heat so recovered was formerly used to heat the anaerobic digesters through external exchangers.

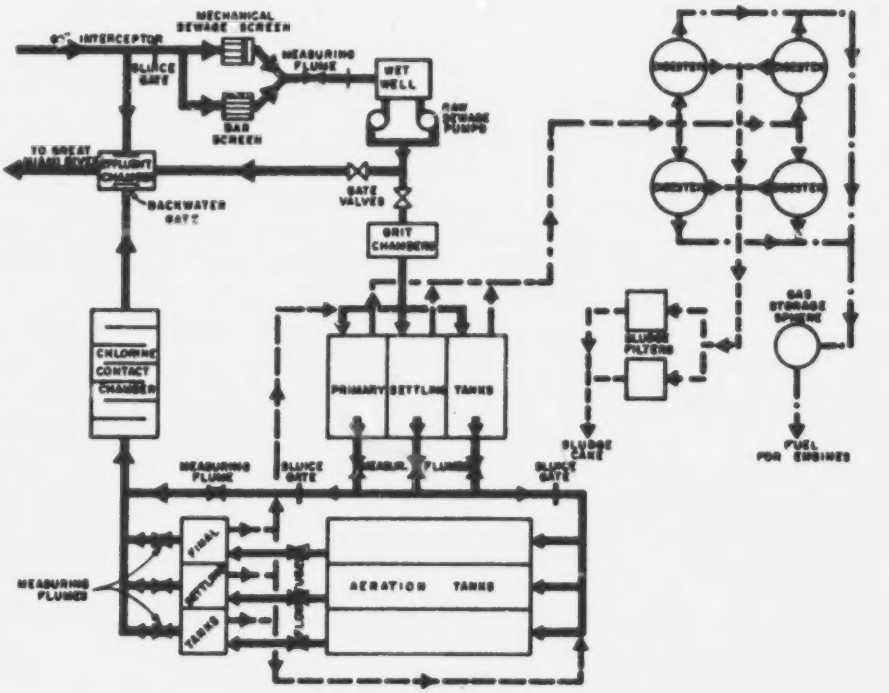

FIGURE 1
PLANT FLOW DIAGRAM

SECTION VI

DIGESTER CONVERSION

The plant incorporated four anaerobic digesters, each 80 feet in diameter with 24 foot sidewater depth and an effective volume of 130,000 cubic feet. All four digesters were equipped with floating covers, and piping arrangement allowed any tank to operate either as a primary or secondary digester. Under anaerobic digester operation two were operated as primary and two as secondary. Heating of primary digesters is accomplished by means of two pipe heat exchangers utilizing waste engine jacket water heat as the heat source. The waste engine heat is more than adequate for total demand for both raw sludge heating and radiation loss. Digester gas produced, in combination with make up natural gas, provide the engine fuel source.

Prior to actual conversion to heated aerobic digesters it was determined that three of the existing four tanks would be utilized, two as aerobic digesters and one as a holding tank. This determination was based on following Table 1, forming a part of the Grant application.

TABLE 1

SCHEDULE OF EXPERIMENTAL PROCEDURES

AEROBIC DIGESTION DEMONSTRATION PROJECT

HAMILTON, OHIO, WASTE TREATMENT PLANT

PROCEDURES

The following specific test procedures apply to the full scope of the project:

Physical Arrangement

Existing Anaerobic Digesters Converted	3
Converted To Aerobic Digesters	2
Converted To Holding Tank	1
Effective Volume Of Aerobic Digesters Each	86,700 Cu. Ft. (650,000 Gal.)
Effective Volume Of Holding Tank	77,700 Cu. Ft. (583,000 Gal.)

Air Rates

Minimum To Either Aerobic Digester	20 cfm/1,000 Cu. Ft.
Maximum To Either Aerobic Digester	45 cfm/1,000 Cu. Ft.

Operation

One aerobic digester will be operated as the "controlled" tank in which the various phases of the test and experimental work will be performed. The second will be operated as an "uncontrolled" tank, receiving any excess of materials produced above that being applied to the "controlled" tank. The holding tank will receive material from both aerobic digesters, and will function to decant excess liquid and to supply vacuum filters.

TABLE 1 (Continued)

The same temperatures and air rates applied to the controlled tank will be maintained in the uncontrolled tank, so that, with the exception of residence time, material produced from both will be under similar conditions. This is necessary inasmuch as vacuum filters will receive combined material from the two tanks.

Materials To Be Tested

(1) Combined primary and waste activated sludge (referred to as CS hereafter)

Temperature Conditions

(1) Ambient (temperature naturally established in digester climate without auxiliary heating . . . probably in range of 55 - 65 degrees F.)

(2) Contents heated to 75 degrees F.

(3) Contents heated to 90 degrees F.

Residence Time (See Qualifications)

(1)	Minimum	-	10 Days
(2)	Average	-	15 Days
(3)	Maximum	-	20 Days

Air Application

(1) Average Rate - 20 cfm/1,000 Cu. Ft. Of Tank (Considered Standard For Mixing)

(2) Increased Rate - 30 cfm/1,000 Cu. Ft. Of Tank

(3) High Rate - 45 cfm/1,000 Cu. Ft. Of Tank

TABLE 1 (Continued)

PHASES OF OPERATION

For identification, the experimental work will be divided into three phases, referenced to the temperature condition. Under each phase, various stages are included, reflecting: residence time and air application rates. Phases, source of material and method of application follow.

Phase I

Material ..... CS

Temperature ..... Ambient (55 Degrees To 65 Degrees F.)

Source ..... Raw Sludge From Primary Tanks As Produced By Normal Practice Of Returning Waste Activated Sludge (WAS) To The Primary and Settling In Conjunction With Raw Waste Solids.

Application ..... Amount As Required Applied To The Controlled Digester, With Excess Directed To The Uncontrolled Tank.

Phase II

Material ..... Same

Temperature ..... Controlled To 75 Degrees F.

Source ..... Same

Application ..... Same

TABLE 1 (Continued)

Phase III

Material ..... Same

Temperature ..... Controlled To 90 Degrees F.

Source ..... Same

Application ..... Same

Summary (See Program Schedule)

QUALIFICATIONS

It must be recognized that during the entire test period over-all plant operation must be such that optimum treatment results are assured and odor nuisance controlled. Should any experimental procedure adversely affect treatment, it may be necessary to temporarily delay the particular procedure until such condition is remedied.

It is possible that availability of material to be tested may limit some stages of experimental procedures, especially so considering that tank volumes, as previously given, are fixed, and that variation in volume of material applied will be the only means to vary residence time. The reported average volume of the CS as produced during the past six months is 54,200 gpd and the controlled digester volume is 650,000 gallons, resulting in 12 days residence time, slightly over the 10 day minimum period tentatively established.

No other limitations are anticipated.

Utilization of the existing digesters to meet the volume requirements established in Table 1, is as shown on Figure 2. Conversion of the structures in this regard consisted merely of positioning the floating covers in a fixed position on the landing brackets, and establishing liquid levels below the cover rims to allow free exhaust of gases to atmosphere.

Other items relative to mechanical revision and additions were done by contract. Bids were received on October 16, 1968 and the low bidder, of $134,000.00, was Antenen Construction Company of Hamilton, Ohio. A contract award was made to this company on November 6, 1968.

The principal item in the conversion to aerobic digesters was the air application equipment. It was obvious that air could only be supplied by external blowers discharging into the covered tanks through some type of diffuser media located in the tank. After consideration of various types of air diffusion equipment available, it was decided that the "Rollaer" system, as manufactured by Walker Process Equipment Division of Chicago Bridge and Iron Company, was most applicable to this somewhat unprecedented

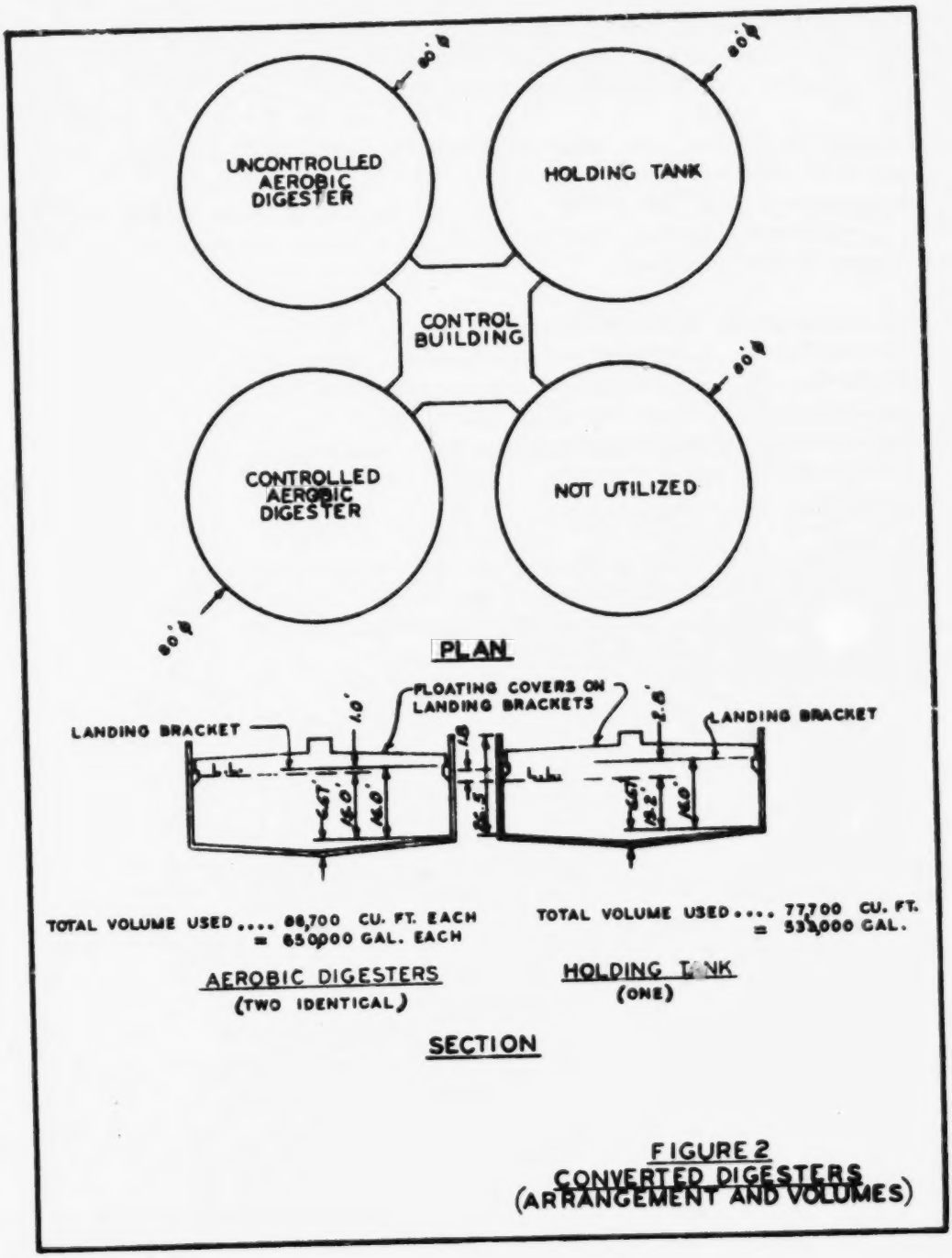

FIGURE 2
CONVERTED DIGESTERS
(ARRANGEMENT AND VOLUMES)

installation. This equipment, as installed in each of the two aerobic digesters, consists of a steel eductor tube, 96 inches in diameter, located at the center of the tank and extending vertically 3 feet off the center of the floor in the digester, to 4.5 feet below the normal water level.

Air from the blower supply is applied through 21 air inductor tubes, with diffuser heads, extending into the eductor tube. The equipment thus has a dual function, operating as an airlift for mixing and agitation, and as a diffusion media for transfer of oxygen to the process.

Air is supplied by three Hoffman centrifugal blowers rated at 3,000 cfm each. Blower output is variable by means of inlet blast gates. Air flow volume is indicated by ammeters calibrated to read free air in cfm. Blowers are mounted on the floating covers and are arranged for each aerobic digester to be supplied by a separate blower. The third blower is a stand-by unit for either tank.

Other conversion items included, revision to existing piping, installation of additional metering equipment, and electrical revision, including larger transformers necessitated by the blower power requirements. Figures 3 and 4, respectively, show diagrammatically the digester arrangement, and the plant flow, after the digester conversion.

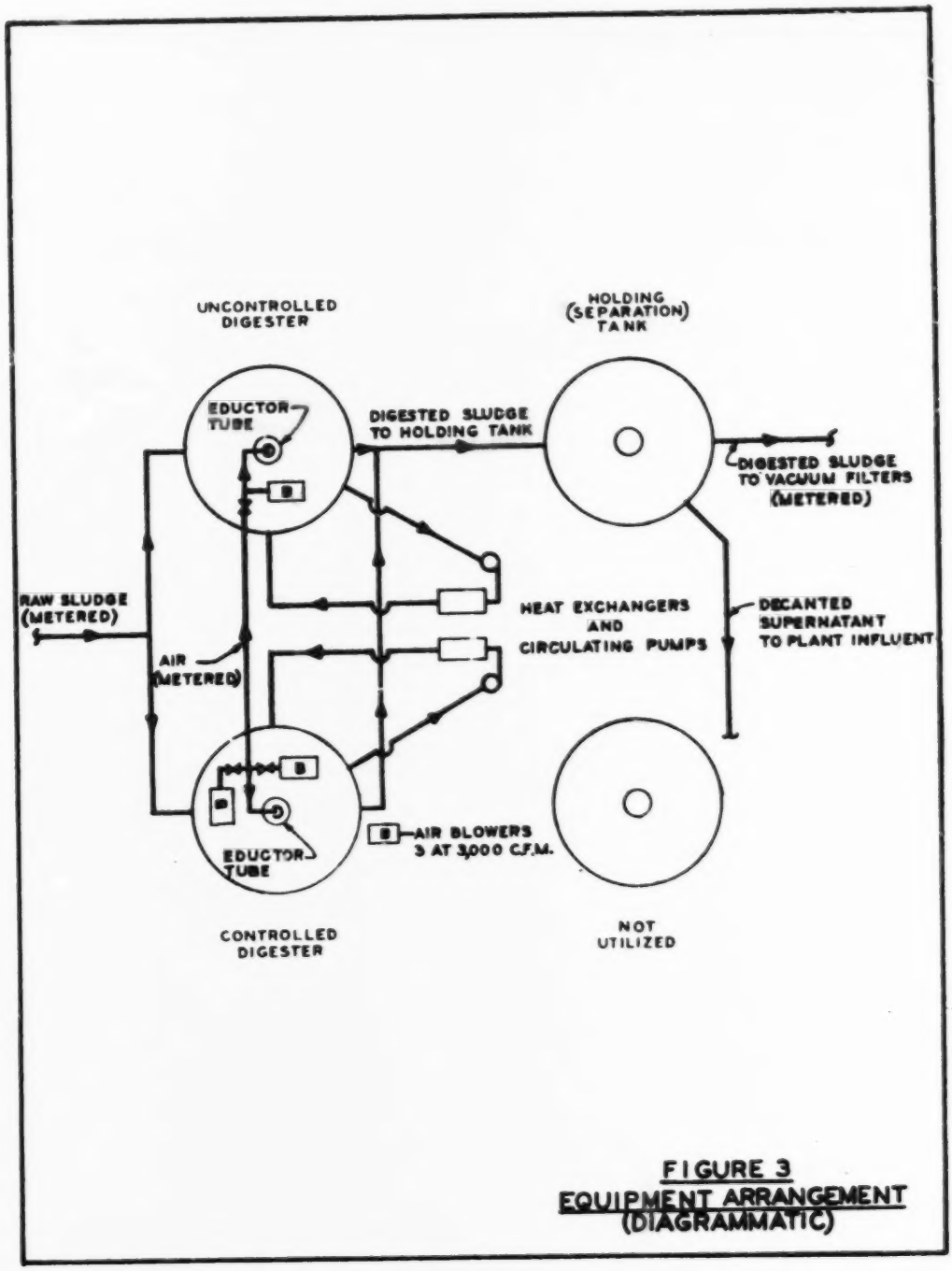

FIGURE 3
EQUIPMENT ARRANGEMENT
(DIAGRAMMATIC)

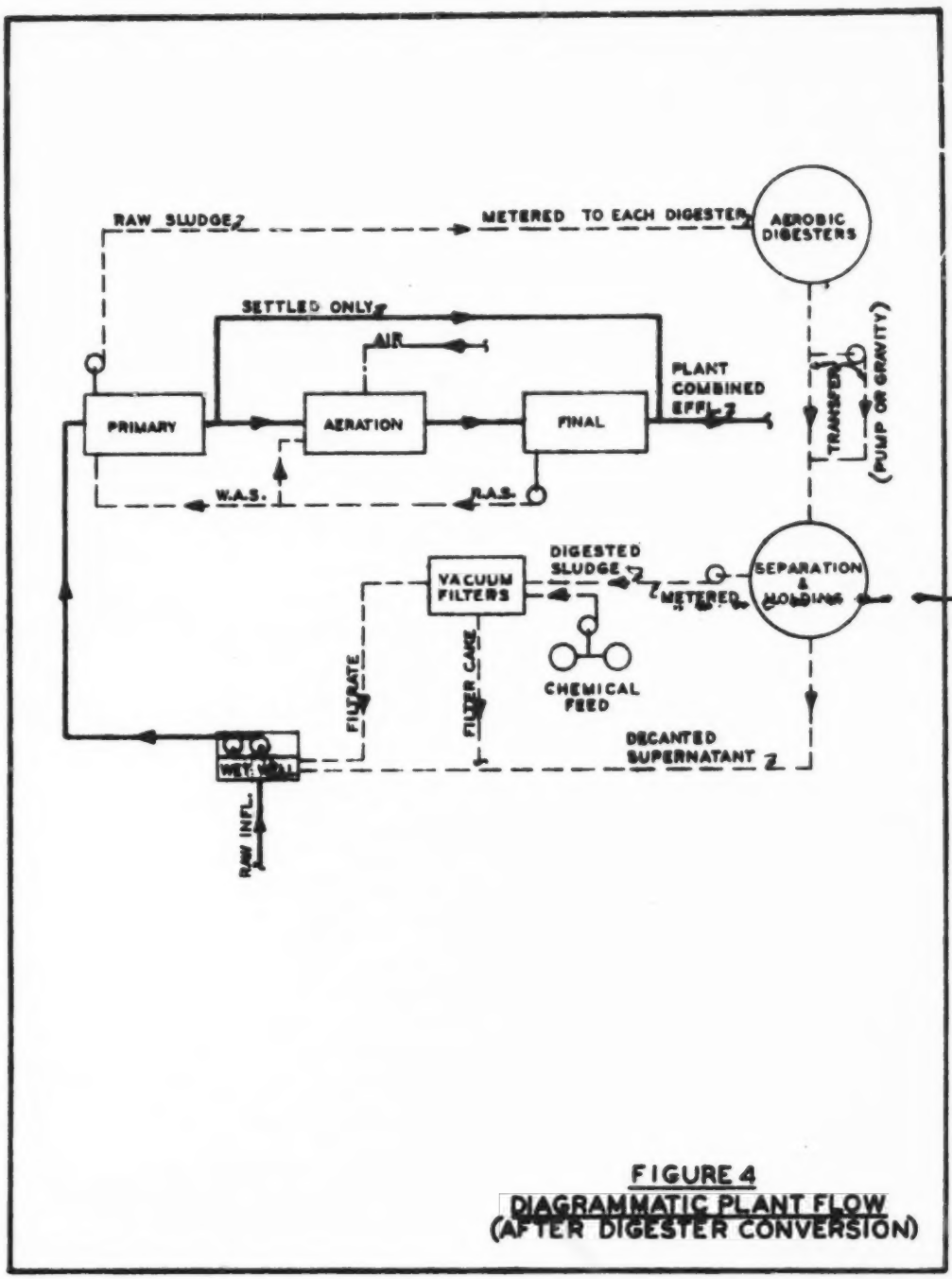

FIGURE 4
DIAGRAMMATIC PLANT FLOW
(AFTER DIGESTER CONVERSION)

Analytical determinations and laboratory facilities requirements, constituted the final major consideration in the conversion program. The original plant included a complete laboratory, normal to the control requirements of the activated sludge process and to anaerobic digestion practices, as employed at the plant. It was evident in early considerations that, although basically adequate, the existing laboratory staffing and equipment could not be expected to handle the volume of determinations that might be required.

Following several joint meetings with FWQA personnel, a schedule was developed both for analyses required and frequency of such determinations. Figure 5, Daily Report Form following, is indicative of such requirements. In addition to data shown, Taft Engineering Center (FWQA) would identify bacteria and type of life from samples to be submitted when any significant changes in digester condition and operation occur. From this schedule additional laboratory equipment was determined and obtained, and staffing was increased to provide man hours estimated. Space for additional equipment proved critical, but this was solved by converting a hallway or corridor to a laboratory annex.

CONSULTING ENGINEERS
TOWNSEND AND ASSOCIATES
CHICAGO

PROJECT HAMILTON, OHIO ..... OF .....
SUBJECT RESEARCH AND DEVELOPMENT ..... DESIGNED MWR DATE .....
GRANT - AEROBIC DIGESTION ..... CHECKED CDW DATE .....

DAILY REPORT

KEY SHEET FOR FREQUENCY OF DETERMINATIONS

Date _____
Phase ____ Stage ____ (____ day of stage)
Digester Temperature ____ °F.... Air Rate / 1000 cu ft of tank ____ cfm
Residence Time { Controlled Digester..... ____ days (vol. = 650000 gal)
Uncontrolled Digester.... ____ days (vol. = 650000 gal)

Total Raw Sludge to Digesters..... daily gpd } Input
Raw Sludge to Controlled Digester..... daily gpd } Input
Raw Sludge to Uncontrolled Digester.. daily gpd } Input
Digested Sludge to Vacuum Filters ... daily gpd } Output
Filtrate (vacuum filters)..... daily gpd } Return to Treatment
Supernatant (holding tank)..... daily gpd } Return to Treatment

	Prim. Dig. Infl.	Prim. Dig. Effl.		Dig. Sludge to Vac. Filt.	Vac. Filt. Output	Vac. Filt. Filtrate	Hold. Tank Supernat.
		Controlled	Uncontrolled				
Total Solids { % / lbs	daily	daily	daily	daily	daily		
Susp. Solids { mg/l / lbs						daily	daily
Vol. Solids (%)	daily	daily	daily	daily	daily	daily	daily
BOD { mg/l / lbs	1/wk	1/wk	1/wk	1/wk			1/wk
COD { mg/l / lbs	1/wk	1/wk	1/wk	1/wk		1/wk	1/wk
Alk. (mg/l)	daily	daily	daily	daily			daily
pH	daily	daily	daily	daily		daily	daily
Ortho PO_4 { mg/l / lbs	1/wk	1/wk		1/wk		1/wk	1/wk
Total PO_4 { mg/l / lbs	1/wk	1/wk		1/wk		1/wk	1/wk
NH_3 { mg/l / lbs	1/wk	1/wk		1/wk			1/wk
NO_2 { mg/l / lbs	1/wk	1/wk		1/wk			1/wk
NO_3 { mg/l / lbs	1/wk	1/wk		1/wk			1/wk
Tot. N { mg/l / lbs	1/wk	1/wk		1/wk			1/wk
Moisture (%)					daily		
Yield (lbs/sq ft/hr)					daily		
CaO (lbs/ton)					daily		
FeCl (lbs/ton)					daily		

FIGURE 5
SCHEDULE OF LABORATORY ANALYSES

SECTION VII

SCOPE OF PROCEDURES

From the procedure schedule shown in Table 1, a detailed testing schedule was developed for implementation of the program. This schedule, shown in Table 2, was divided into three main phases of five stages each. As indicated, the ranges established in Table 1 for time, air rate, and temperature factors, were covered by the schedule. Three weeks for each stage was selected as a reasonable time for evaluation.

TABLE 2

DETAILED TESTING SCHEDULE

Phase / Stage	Residence Time (Days)	Air Rate (CFM Per 1,000 Cu. Ft. Of Tank)	Test Period (Days)	Remarks
I				Temperature - Ambient (55° To 65° F.)
1	*10	20	21	*As close as production of sludge allows
2	15	20	21	
3	20	20	21	
4	*	30	21	*Minimum effective (Stages 1-2-3)
5	*	45	21	*Same as established for Stage 4
			105	
II				Temperature - Controlled 75° F.
1	*	20	21	*Same as established for Stage 1, Phase I
2	15	20	21	
3	20	20	21	
4	*	30	21	*Minimum effective Stages 1-2-3
5	*	45	21	*Same as established for Stage 4
			105	

TABLE 2 (Continued)

Phase / Stage	Residence Time (Days)	Air Rate (CFM Per 1,000 Cu. Ft. Of Tank	Test Period (Days)	Remarks
III				Temperature - Controlled 90° F.
1	*	20	21	*Same as established for Stage 1, Phases I and II
2	15	20	21	
3	20	20	21	
4	*	30	21	*Minimum effective for Stages 1-2-3
5	*	45	21	*Same as established for Stage 4
			105	
SUMMARY	*	*	21	*From Phase I-II-III Select The Most Effective Combination Of (1) Temperature, (2) Residence Time, and (3) Air Rate, For A Summary Test
Total Days			336	

The total time for the project as scheduled was estimated at two years, a breakdown is shown on following Table 3, Time Summary.

TABLE 3

TIME SUMMARY

Planning, Bidding, Construction		180 (6 Months)
Testing (Detailed Schedule Attached)	336	
*Interim Periods	126	
Total Time For Actual Testing Period		462 (15 Months)
Analysis and Report Preparation		88 (3 Months)
Total Project Time		730 (2 Years)

*Interim Periods. A reasonable time period must be provided between stages to allow for material condition change, and between phases to allow temperature change. These intervals are estimated at one week (7 days) between stages and two weeks (14 days) between phases. Four weeks will be required between stages in each of the three phases, and three intervals of two weeks between Phases I, II, III, and Summary. Total lapsed time is 18 weeks (126 days).

SECTION VIII

OPERATION DESCRIPTION AND RESULTS

It had been estimated (Table 3, Time Summary) that operation would start 6 months after project approval had been received and accepted. This proved somewhat optimistic, inasmuch as delays in planning, construction, and equipment delivery and testing, resulting in a starting date on October 18, 1969, approximately 6 months later than the estimated date.

Start-Up Considerations and Procedures

Following preliminary discussions, it was agreed that Tank No. 3 (uncontrolled digester) would be started first, so that it would be immediately available for receiving any excess sludge produced above scheduled test loadings of Tank No. 1 (controlled digester). Following this Tank No. 1 would then be started, and, as soon as satisfactory functioning of the process had been established, the first phase of the testing schedule would be started. Accordingly application of approximately 33,000 gpd of raw sludge to Tank No. 3 was begun on the starting date indicated. On October 25th, one week later, application of a similar volume of raw sludge, 33,000 gpd, was started to Tank No. 1. On October 10th vacuum filtering of aerobically digested sludge from Tank No. 4 (holding tank) was commenced.

Operational Developments

During the start-up period there were some mechanical interruptions, but none considered serious enough to materially affect the process. Various testing and analytical procedures, applicable to this initial period, were instituted and recorded. These were necessarily irregular and could not be considered for the specified program, but were indicative in establishing trends. The most important of these, especially in retrospect were:

1. Gradual increase in solids concentration in both digesters with further increase in holding tank.

2. Steady increase in digester temperature without any heat application except from compressed air.

3. Gradual lowering of SVI in digesters, indicating increased stability.

4. Maintenance of pH in digesters at, or above, pH of raw sludge applied.

5. Increasing difficulty in maintaining DO in either digester, necessitating constant air increase.

6. Extremely obnoxious odor production, apparently increasing in intensity as temperature of digester contents rises.

The undesirable conditions noted continued and in general intensified, to the extent that on November 14th a decision was made to stop feeding the digesters.

The major factor influencing this decision was the extreme odor condition, reaching almost sickening proportions at even remote locations from the plant, despite the fact that an odor masking system, previously installed for sour anaerobic conditions, had been in constant service. At this time digester temperature had approached 100 degrees F, a rise of $\pm$ 30 degrees F from the raw

sludge temperature of 70 degrees F. All three blowers had been in use for several days at a maximum total output of 12,000 cfm, providing 69.2 cfm of air per 1,000 cubic feet of volume in both tanks, however very little more than a trace of DO could be maintained.

Following discontinuance of feeding, the holding tank was drained and cleaned to determine whether or not it was the principle contributor to the odor problem. This provided to be not the case. Aeration of the contents in Tanks No. 1 and 2 continued until the end of December, at which time the volatile matter had been reduced from approximately 70% to 40%. As volatile content regressed it was noted that digester temperature lowered from a high of 105 degrees to 108 degrees F, reached just after feeding was stopped, to approximately 70 degrees F at the end of December. Air rates were gradually decreased to 2,000 cfm per digester by the end of this period, and all odor had disappeared.

It was though possible that overloading during start-up might have occurred, producing conditions from which the digesters were never able to fully recover. After further discussions, it was decided to make a second attempt at reduced loading rates to the now completely stabilized and aerobic tanks. Loading rate at starting in early January, 1970 was 3,000 gpd to Tank No. 1, gradually increasing as conditions warranged. Weekly increases were made until, by the end of February, 1970, a rate of 15,000 gpd had been reached. At this point temperature started to increase rapidly, DO dropped, and extreme odor nuisance reappeared. In brief, conditions attained in the initial trial were repeated. On March 1, 1970, raw sludge feeding was stopped, and shortly thereafter elutriation of the tank with plant effluent was made to reduce odor conditions.

Reports of operation for the months of November and December, 1969, and January, February, March, April, and May, 1970 are included in the Appendix. These are indicative of the above noted conditions. It is also noted that no further material was fed to the digesters after the March discontinuance, and operation from this time to the final report of May, 1970 was in the nature of stabilizing the tank contents by air application.

SECTION IX

BACTERIAL ENERGY

During the stabilizing period following the second attempt to establish the process, a meeting was held at the plant with FWQA personnel to discuss the heat factor, its source, and possible control. Prior to this meeting on March 18, 1970, calculations had been made of heat introduced by compressed air application, and it had been determined that this could account for only a small part of the heat required to bring the digesters up to the temperatures obtained. In the absence of any other heat application, it was agreed that heat produced from bacterial energy in reduction of the volatiles must be the source. Inasmuch as very little has been previously established on this phenomenon, it was believed that data obtained from this operation might provide valuable information. Accordingly, Consoer, Townsend and Associates, Consulting Engineers for the City of Hamilton on this project, made a series of calculations culminating in a letter report submitted to Mr. Harold W. Augenstein, Project Director for the City, under date of March 30, 1970. A transcript of that letter, with attached calculations is included in the Appendix.

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SECTION X

TERMINATION OF PROJECT, SUMMARY AND COMMENTS

On April 27, 1970, a joint meeting of City, FWQA, and consultant personnel was scheduled at the Hamilton plant. After a discussion covering all aspects to date, it was agreed that the program procedures as established could not be carried out, due to inability to control digester temperatures to various ranges. It was also not believed advisable to attempt further exploration in the thermophilic range at 110 degrees F up, in view of the intense odor conditions developing at higher temperatures.

In this accord a written request for termination of the project was made by the City of Hamilton. A copy of this letter, addressed to Mr. Robert L. Feder, Project Officer for FWQA, and signed by Mr. Harold W. Augenstein, Project Director for the City, is included in the Appendix. This letter also provides a chronological outline of the project procedures.

Official termination notification for the project was received by the City in a letter from FWQA under date of June 23, 1970. The termination date was given as of the close of business on June 18, 1970.

Summary

In summary, the original concept of the project was never obtained due to temperature conditions. Data of some value was obtained, however, including heat produced by bacterial energy. In addition, reasonably conclusive data is established on odor nuisance proclivities when approaching the thermophilic range on full plant scale operation.

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Comments

As an effort to control digester temperature, it was suggested at one of the joint meetings that air cooling with an exhaust fan might be effective. Although calculations indicated that this would be inadequate, it was given a trial. A 5,000 cfm exhaust fan was installed to take suction from a cover manhole, thus drawing cooling air across the liquid surface from the annular space between the floating cover rim and the tank wall. The temperature differential between the liquid and the air was so close, however, that little if any benefit resulted.

SECTION XI

ACKNOWLEDGEMENTS

The City of Hamilton wishes to acknowledge and thank the many people who contributed information in making this project possible. This includes personnel from the Federal Water Quality Administration, Taft Environmental Health Center, Consoer, Townsend and Associates, Walker Process Equipment Company, City of Hamilton including Wastewater Treatment Plant and the Ohio Department of Health.

Individual recognition should be given to Mr. John Stamberg, Mr. Robert L. Feder, Mr. Eugene Harris and Dr. Ronald Lewis of FWQA; Mr. Carl D. Wright of Consoer, Townsend and Associates; Messrs. Earl Brush, John Engle, Harold W. Augenstein and Thomas Harrell of the City of Hamilton; Mr. Robert Booth, Regional AQC Coordinator; and Prof. John F. Andrews, Clemson University.

Officers of the Project were as follows:

Project Officer	--	Robert L. Feder
Project Director	--	Harold W. Augenstein
Grant Directors	--	Earl Brush and John Engle
Financial Officer	--	Charles Rupert

SECTION XII

REFERENCES

1. Carpenter, W. L., and Blosser, R. O., Aerobic Decomposition Of Secondary Papermill Sludges, Proceedings of the 17th Industrial Waste Conference, Purdue University, 1962, Pages 126-135.

2. Dreier, D. E., Aerobic Digestion Of Solids, Proceedings Of The 18th Industrial Waste Conference, Purdue University, 1963, Pages 123-140.

3. Kambu, K., and Andrews, J. F., An Aerobic Thermophilic Process For The Biological Treatment Of Wastes - Simulation Studies, A Publication Of The Environmental Systems Engineering Department, Clemson University.

4. Loehr, R. C., Aerobic Digestion: Factors Affecting Design, Water and Sewage Works, Reference Number, November, 1965.

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SECTION XIII

APPENDICES

1. Daily Operating Reports
   November, 1969 through May, 1970

2. Letter and Calculations (March 30, 1970)
   On Heat Produced By Bacterial Energy

3. Letter (May 8, 1970) Requesting Project
   Termination (Includes Resume Of Project)

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REPORT OF OPERATION ON FEDERAL GRANT

CITY OF HAMILTON, OHIO
WASTEWATER TREATMENT PLANT
MONTH OF November 1960

Date	TOTAL SOLIDS			VOLATILE SOLIDS			ALKALINITY			pH		DOs		TEMP.		BODs		#	NUTRIENTS						COD:	Flow					
	Raw	Dir. #1	Dir. #3	Raw	Dir. #1	Dir. #3	Raw	Dir. #1	Dir. #3	Dir. #1	Dir. #3	Dir. #1	Dir. #3	Dir. #1	Dir. #3	Dir. #1	Dir. #3	Direster	NO_2	NO_3	NH_3	Total Nitrogen	PO_4 Ortho	PO_4 Total							
1							2200	530	382	6.7	6.2																				
2							2200	530	382	6.7	6.2																				
3	1.1	1.3	3.0	71.5	66.7	60.0	2000	650	256	6.3	6.0			85	89															
4	4.3	1.1	1.8	66.7	66.7	60.0	2070	540	566	6.3	6.1			85																
5	2.2	1.6	1.7	66.7	75.0	60.0	1550	353	386	6.2	6.4			85																
6	4.1	2.3	2.0	63.4	66.7	60.0	1376	274	413	6.0	6.2			85	89															
7							1370	437	207	65	5.6			86	90															
8							1370	437	207	6.5	5.6			91	96															
9	3.7	4.2	2.4	60.0	60.0	71.5	1370	437	207	6.5	5.8			89	94															
10	4.1	1.5	2.2	58.4	-	67.0	1000	192	0	5.9	5.2			91	96															
11	1.9	1.2	1.4	65.0	69.7	68.8	1090	800	401	7.0	6.1			94	97															
12	4.1	2.4	1.3	72.8	-	80.0	780	720	345	6.2	6.7	7.0	6.1	96	97															
13	4.4	2.0	1.4	70.0	80.0	75.0	840	931	570	7.2	7.8			96	98															
14							950	847	620	7.2	7.0			96	97	280	420	371	366											
15							950	847	620	72.	7.0			95	96															
16	4.4	2.2	1.9	60.0	50.0	60.0	950	847	620	7.2	7.0			96	98															
17	-	1.9	1.6	-	75.0	75.0	-	870	1043	7.2	7.3			98	100															
18	-	1.5	2.2	-	75.0	67.0	-	800	1252	7.6	7.8	0.5	0.7	101	102															
19	-	1.8	2.2	-	75.0	70.0	-	1400	1515	7.4	7.8			103	103															
20	-	2.3	1.9	-	66.7	80.0	-	900	1170	6.6	7.6			104	102															
21							-	850	1750	7.0	7.8			105	102	354	316	732	742											
22							-	850	1750	7.0	7.8			106	103															
23	-	1.3	0.7	-	66.7	50.0	-	850	1750	7.0	7.8			107	104															
24	-	1.3	1.4	-	88.4	-	-	900	1575	7.1	7.7			108	104															
25	-	1.1	2.4	-	40.0	66.7	-	600	1400	6.7	7.9	2.5	0.7	107	104															
26							-	310	1050	7.0	7.9			107	104															
27	-	3.1	3.5	-	60.0	62.5	-	310	1050	7.0	7.9	3.6	1.2	107	104															
28							-	580	1150	7.0	8.3			106	103															
29							-	580	1150	7.0	8.3			106	103															
30	-	1.4	2.1	-	66.7	50.0	-	590	1150	7.0	8.3			105	102															
31																														
TOT																														
AVE.																														

REPORT OF OPERATION ON FEDERAL GRANT

CITY OF HAMILTON, OHIO
WASTEWATER TREATMENT PLANT
MONTH OF December 1969

Date	TOTAL SOLIDS			VOLATILE SOLIDS			ALKALINITY			pH		DOs		TEMP.		BODs		#	NUTRIENTS										
	Raw	Dig. #1	Dig. #3	Raw	Dig. #1	Dig. #3	Raw	Dig. #1	Dig. #3	Dig. #1	Dig. #3	Dig. #1	Dig. #3	Dig. #1	Dig. #3	Dig. #1	Dig. #3	Digester	NO_2 -	NO_3 -	NH_3 -	Total Nitrogen	PO_4 Ortho	PO_4 Total	CODs	Flow				
1		1.6	2.1		51.3	55.7		910	-	7.7	8.1			103	102														
2		1.7	2.1		52.1	54.0		1000	1170	7.7	7.5			102	102														
3		1.6	2.0		47.7	45.6		1100	970	8.6	7.3	2.5	1.0	102	103														
4		1.6	2.4		47.5	49.9		900	830	7.7	7.3			100	102														
5								1180	1130	8.1	7.9			99	102	370	349												
6								1180	1130	8.1	7.9			98	103														
7		1.9	1.8		47.5	46.5		1330	1180	8.3	8.2	3.0	1.2	96	102														
8		1.4	1.9		43.8	42.0		1180	1130	8.1	7.9	4.0	1.5	97	102														
9		1.5	1.7		43.5	45.7		1340	1400	8.2	8.3	2.3	1.4	96	102														
10		1.5	1.6		43.8	43.7		690	1000	7.5	8.4			94	102														
11		1.4	0.5		45.0	45.0		610	3550	6.5	8.5			92	101	105	319	50											
12								1330	1180	6.8	8.4			89	101														
13								610	2550	6.5	8.5			87	100														
14		1.5	1.8		47.5	43.8		610	2550	6.5	8.5	8.0	7.0	85	98														
15		1.2	2.0		40.2	34.2		600	2480	6.8	8.9			83	94														
16		1.5	1.7		42.3	40.7		708	2400	6.5	8.9	9.7	6.4	82	80														
17		1.5	1.7		43.9	39.3		600	2720	6.5	8.7	9.2	6.5	80	88														
18		2.0	2.4		56.7	58.3		530	2150	6.3	8.6			79	86														
19								500	1750	6.8	8.6	10.0	8.1	78	82	300	443												
20								500	1750	6.8	8.6			77	81														
21		1.7	1.9		42.5	38.7		500	1750	6.8	8.6			76	81														
22		1.9	1.6		43.5	36.9		430	660	6.2	6.8	11.0	9.4	75	77														
23		1.4	1.7		-	-		600	560	6.2	5.4	10.3	9.1	74	69														
24								590	600	6.6	6.9			72	67														
25		1.4	1.2		42.0	40.0		590	600	6.6	6.9	9.3	9.0	71	69														
26								705	650	6.9	6.7			71	73														
27								706	650	6.9	6.4			70	74														
28		1.6	1.6		58.1	70.7		705	650	6.9	6.4	8.3	9.3	69	71														
29		1.4	1.7		54.7	48.4		585	600	6.6	6.6			68	71														
30		1.4	1.7		56.3	47.5		515	610	6.5	6.7	9.4	9.4	68	60														
31														67	8-														
TOT.																													
AVE.																													

REPORT OF OPERATION ON FEDERAL GRANT

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CITY OF HAMILTON, OHIO
WASTEWATER TREATMENT PLANT
MONTH OF January 1970

Date	TOTAL SOLIDS			VOLATILE SOLIDS			ALKALINITY			pH		DOs		TEMP.		BODs		#	NUTRIENTS									
	Raw	Dig. #1	Dig. #3	Raw	Dig. #1	Dig. #3	Raw	Dig. #1	Dig. #3	Dig. #1	Dig. #3	Dig. #1	Dig. #3	Dig. #1	Dig. #3	Dig. #1	Dig. #3	Digester	NO_2	HC_3	H_3	Total Nitrogen	PO_4 Ortho	PO_4 Total	CODs	Flow			
1		1.4	1.7		41.3	39.9		480	520	6.8	6.8	8.2	9.0	67	66													
2		1.1	1.2		41.9	39.9		590	510	7.1	6.7	9.2	10.8	67	70													
3		1.1	1.2		41.9	39.9		590	510	7.1	6.7	9.2	10.8	67	67													
4		1.1	1.2		41.9	39.9		590	510	7.1	6.7	9.2	10.8	67	67													
5		1.5	1.7		40.6	39.4		560	450	7.0	6.8	-	-	66	61													
6		1.4	1.7		42.4	40.1		560	560	7.1	6.9	-	-	66	53													
7		1.3	1.6		38.5	38.1		495	470	7.1	6.7	-	-	65	52													
8		1.4	1.6		40.2	38.0		575	500	7.0	6.7	8.4	9.2	64	52													
9		1.6	1.0		41.9	40.9		620	550	6.7	6.7	9.8	11.2	63	52			Raw	35.0		60.2	560	333	683	42	16		
10		1.6	1.0		41.9	40.9		620	550	6.7	6.7	9.8	11.2	62	47			#1	14.0		71.1	512	250	300	11	82	3000	
11		1.6	1.0		41.9	40.9		620	550	6.7	6.7	9.8	11.2	62	47			#3							90	62		
12		1.4	1.6		41.9	40.3		575	600	6.6	6.8	-	-	62	52													
13	3.0	1.4	1.6	72.4	42.8	39.9	1250	520	600	6.5	6.7	8.6	10.4	61	54													
14	3.8	1.4	1.5	68.1	43.7	40.9	2100	500	650	6.4	6.7	9.2	11.0	61	54													
15	4.9	1.4	1.8	70.2	56.8	41.0	2340	500	580	6.4	6.7	9.0	10.5	61	55													
16	2.3	2.6	1.0	57.1	42.8	43.1	1150	700	500	6.6	6.7	9.6	8.5	61	57	6810	5804	90										
17	2.3	2.6	1.0	57.1	42.8	43.1	1150	700	500	6.6	6.7	9.6	8.5	61	57												4500	
18	2.3	2.6	1.0	57.1	42.8	43.1	1150	700	500	6.6	6.7	9.6	8.5	61	57													
19	4.0	1.3	1.7	74.0	42.8	37.4	1900	605	900	6.9	7.3	10.6	9.6	62	51			Raw	17.5		85.7	655	512	688	45	12		
20	2.6	1.0	1.6	75.0	43.7	38.9	1060	245	550	6.2	6.8	11.2	8.6	61	50			#1	17.5		71.2	289	325	675	102	90		
21	2.8	1.5	1.6	71.7	42.8	37.5	1080	390	730	6.2	7.1	11.8	10.0	60	48			#3							84	65		
22	3.2	0.5	1.6	75.3	59.0	63.0	1150	420	680	6.3	6.9	10.7	9.2	59	46													
23	2.9	1.0	1.2	73.1	45.4	38.8	1570	340	630	6.4	7.2	10.4	10.0	58	44													
24	2.9	1.0	1.2	73.1	45.4	38.8	1570	340	630	6.4	7.2	10.4	10.0	58	45	4240	5302	90										
25	2.9	1.0	1.2	73.1	45.4	38.8	1570	340	630	6.4	7.2	10.4	10.0	58	44												6000	
26	2.8	1.5	1.6	76.0	45.0	35.4	1160	435	720	6.4	7.1	10.3	10.6	58	52			Raw			86.4		313	600	39	40		
27	2.7	1.4	1.8	78.4	45.3	38.1	1100	460	680	6.5	7.1	10.8	10.5	58	53			#1			86.6		92	425	60	12		
28	3.6	1.7	1.9	76.6	46.0	36.3	1300	550	790	6.7	7.1	9.8	10.2	58	51			#3							84	65		
29	4.6	1.2	1.3	67.8	43.7	49.1	2070	350	600	6.4	6.9	9.8	9.8	59	53													
30	3.8	1.5	1.6	69.2	47.1	43.9	1370	220	500	6.4	6.6	9.1	11.0	60	54													
31	3.8	1.5	1.6	69.2	47.1	43.9	1370	220	500	6.4	6.6	9.1	11.6	60	51	6330	6674	45										
TOT	81.2	45.3	44.6	2334.5	1300.2	1260.3	27420	15431	13240					1913	50													
AVE	3.2	1.5	1.6	77.8	43.3	40.9	1243	495	565	6.4	6.8	9.7	10.1	62	1666			Raw	25.2		80.8		553	657	42	93	7500	
															54	6791	5922	#1	15.7		69.6		222	867	94	68		
																		#3							88	37		

REPORT OF OPERATION ON FEDERAL GRANT

CITY OF HAMILTON, OHIO
WASTEWATER TREATMENT PLANT
MONTH OF **February 1970**

Date	TOTAL SOLIDS			VOLATILE SOLIDS			ALKALINITY			pH		DOs		TEMP.		BODs		#	NUTRIENTS								
	Raw	Dig. #1	Dig. #3	Raw	Dig. #1	Dig. #3	Raw	Dig. #1	Dig. #3	Dig. #1	Dig. #3	Dig. #1	Dig. #3	Dig. #1	Dig. #3	Dig. #1	Dig. #3	Digester	NO_2	NO_3	NH_3	Total Nitrogen	P_h Ortho	PO_h Total	CODs	Flow				
1	3.8	1.8	1.6	69.2	47.1	43.9	1370	220	500	6.3	6.4	9.1	11.6	60	51														
2	3.9	1.4	1.6	70.9	47.3	36.9	1770	400	500	6.4	6.5	8.0	9.7	61	50														
3	2.9	1.5	1.6	65.4	48.5	36.2	1200	360	450	6.4	6.5	8.3	10.9	61	44			Raw							30400				
4	3.7	1.5	1.4	68.5	50.7	63.3	1600	430	640	6.3	6.4	9.5	12.7	61	46			#1			54.7	3818			10400				
5	4.3	1.7	1.5	68.8	50.3	38.6	1810	425	520	6.2	6.3	9.0	12.6	61	49										8000				
6	5.3	1.9	1.9	68.3	39.0	51.2	2200	460	450	6.8	6.6	7.0	10.8	61	50	383	170	Raw	1.9	5.7									
7	5.3	1.9	1.9	68.3	39.0	51.2	2200	460	450	6.8	6.6	4.0	10.8	62	50			#1	159	129							0500		
8	5.3	1.9	1.9	68.3	39.0	51.2	2200	460	450	6.8	6.6	4.0	10.8	62	52			Raw	8.6	13.0									
9	4.1	1.7	1.5	70.6	52.7	63.7	1800	400	520	6.6	6.7	8.2	13.0	63	53			#1	119	112									
10	4.5	2.1	1.7	70.7	52.9	37.2	2020	645	420	6.8	6.6	7.8	11.7	64	52														
11	3.9	1.5	1.6	72.8	54.4	37.0	1580	460	530	6.8	6.6	7.4	11.1	65	51														
12	3.0	1.8	1.5	69.4	56.2	36.6	1520	505	560	6.5	6.4	7.7	12.2	65	49			Raw	0.6	0.7		890			50000				
13	3.8	0.5	1.1	70.3	48.2	43.3	1730	230	450	6.5	6.7	6.1	12.2	66	48			#1	105	98	458	460			13700				
14	3.8	0.5	1.1	70.3	48.2	43.3	1730	230	450	6.5	6.7	6.1	12.2	66	45			#3							5430	13500			
15	3.8	0.5	1.1	70.3	48.2	43.3	1730	230	450	6.5	6.7	6.1	12.2	66	47														
16	4.8	1.8	1.4	70.0	56.0	35.2	1850	490	520	6.8	6.5	5.8	10.7	67	48														
17	4.8	1.7	1.4	69.4	55.6	37.7	1900	500	520	6.9	6.5	4.8	10.2	68	47														
18	5.2	1.7	2.5	69.2	47.2	35.8	2150	470	620	6.8	6.4	5.8	11.4	70	49														
19	4.7	1.8	1.2	71.8	57.8	36.4	2170	480	520	6.9	6.5	6.0	10.0	70	49			Raw							50212				
20	3.7	2.0	1.6	71.2	55.8	39.0	1340	390	450	7.3	6.7	5.6	11.6	71	46	860	177	#1							6303				
21	3.7	2.0	1.6	71.2	55.8	39.0	1340	390	450	7.3	6.7	5.8	11.6	71	47			#3							7842	13900			
22	3.7	2.0	1.6	71.2	55.8	39.0	1340	390	450	7.3	6.7	2.0	11.6	72	49											14400			
23	3.7	2.0	1.6	71.2	55.8	39.0	1340	390	450	7.3	6.7	1.4	11.6	74	50											14900			
24	4.6	1.9	1.6	71.7	57.0	38.1	1730	915	580	7.7	6.7	2.0	9.6	75	49											15300			
25	4.9	1.9	3.3	72.4	57.0	16.8	1500	805	580	7.7	6.7	2.0	10.9	78	46											15600			
26	3.8	1.8	1.5	71.5	57.8	38.5	1800	935	580	7.4	6.6	1.3	10.8	80	48			Raw	802		1420	802			89500	15600			
27	5.1	1.2	1.3	70.7	57.3	38.1	1950	820	480	7.2	6.6	1.2	12.4	82	50			#1			425	320			11615	15600			
28	5.1	1.2	1.3	70.7	57.3	38.1	1950	820	480	7.2	6.6	0.5	12.4	83	50			#3							7250	15600			
29																													
30																													
31																													
TOT																													
AVE	4.3	1.6	1.8	70.2	52.1	41.8	1756	490	499	6.8	6.6	5.5	11.4	68	49	630	247												

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REPORT OF OPERATION ON FEDERAL GRANT

CITY OF NAPOLEON, OHIO
WASTEWATER TREATMENT PLANT
MONTH OF March 1978

Date	TOTAL SOLIDS			VOLATILE SOLIDS			ALKALINITY			pH		DOs		TEMP.		BODs		#	NUTRIENTS							
	Raw	Dig. #1	Dig. #3	Raw	Dig. #1	Dig. #3	Raw	Dig. #1	Dig. #3	Dig. #1	Dig. #3	Dig. #1	Dig. #3	Dig. #1	Dig. #3	Dig. #1	Dig. #3	Digester	NO_2	NO_3	NH_3	Total Nitrogen	PO_4 Ortho	PO_4 Total	CODs	Flow
1	5.2	1.2	1.3	70.7	57.3	38.1	1950	520	480	7.2	6.6	1.2	12.4	86	51											5200
2		1.3	1.5		54.7	36.9		915	590	7.4	6.6	.3	11.4	88	54											
3		1.6	1.6		56.8	39.0		950	570	7.4	6.5	.4	10.7	91	55											
4		1.7	1.6		54.5	40.1		1055	570	7.2	6.6	.4	10.8	93	57			Raw				1240				
5		1.8	1.6		52.5	36.6		1095	560	7.5	6.5	.6	10.1	95	53			#1	66	11.3	13.9			7804		
6		1.9	1.4		51.5	36.1		1220	580	7.3	6.6	.6	10.4	96	54	164	57	#3				330		1066		
7		1.9	1.4		51.5	36.1		1220	580	7.3	6.6	.6	10.4	97	56									7426		
8		1.9	1.4		51.5	36.1		1220	580	7.3	6.6	.9	10.0	99	56											
9		1.7	1.5		49.3	36.3		1065	580	7.0	6.6	.5	11.1	100	52											
10		1.3	1.6		42.4	-		845	570	6.9	6.4	.6	10.9	97	50											
11		1.1	1.5		46.9	37.4		740	520	7.4	6.4	.4	10.0	92	50											
12		0.9	1.6		45.2	35.8		800	550	7.5	6.6	4.4	11.4	89	49			#1	6.0	1.7	19.8	54		9752		
13		1.0	1.1		41.0	46.5		820	480	7.4	6.5	2.0	11.8	87	51	201	75	#3						6836		
14		1.0	1.1		41.0	46.5		820	480	7.4	6.5	2.0	11.8	88	52											
15		1.0	1.1		41.0	46.5		820	480	7.4	6.5	2.0	11.8	88	51											
16		1.0	1.5		43.2	37.7		735	470	7.5	6.4	3.2	11.2	88	51											
17		1.0	1.5		46.8	40.6		795	500	7.5	6.4	3.8	11.4	88	51											
18		1.0	1.5		40.8	36.4		760	500	7.5	6.5	5.2	10.4	88	53											
19		1.0	1.5		40.5	37.5		695	510	7.5	6.4	6.0	9.4	88	56			#1	9.2	52	3	100	16.8	4259		
20		0.9	1.1		40.0	37.1		650	540	7.4	6.5	5.8	7.4	87	62	540	353	#3	17.3	86	3			5234		
21		0.9	1.1		40.0	37.1		650	540	7.4	6.5	5.8	7.4	86	67											
22		0.9	1.1		40.0	37.1		650	540	7.4	6.5	6.8	7.4	85	71											
23		1.0	1.4		40.2	37.0		500	450	7.4	6.5	6.4	6.1	84	77											
24		1.1	1.3		38.1	27.6		575	600	7.0	6.5	7.2	6.2	83	79											
25		1.6	1.6		39.8	37.1		600	560	7.3	6.4	7.4	3.2	82	84											
26		1.0	1.5		37.8	37.5		615	450	7.2	5.9	7.6	5.0	81	86			#1	0.1	16	4	123	1.1	4600		
27		1.0	1.5		37.8	37.5		615	450	7.2	5.9	5.8	5.6	80	89			#3	2.9	53	9			6800		
28		1.0	1.5		37.8	37.5		615	450	7.2	5.9	7.6	5.4	78	91											
29		1.0	1.5		37.8	37.5		615	450	7.2	5.9	8.8	5.8	78	93											
30		1.1	1.2		39.5	40.6		545	270	6.7	6.7	7.1	6.3	78	94											
31		1.0	1.6		38.4	39.4		595	120	7.1	5.2	7.4	6.0	78	94											
TOT																										
AVE																										

REPORT OF OPERATION ON FEDERAL GRANT

Reproduced from best available copy.

CITY OF HAMILTON, OHIO
WASTEWATER TREATMENT PLANT
MONTH OF April 1970

Date	TOTAL SOLIDS			VOLATILE SOLIDS			ALKALINITY			pH		DOs		TEMP.		BODs		#	NUTRIENTS							Flow
	Raw	Dir. #1	Dir. #3	Raw	Dir. #1	Dir. #3	Raw	Dir. #1	Dir. #3	Dir. #1	Dir. #3	Dir. #1	Dir. #3	Dir. #1	Dir. #3	Dir. #1	Dir. #3	Diverter	NO_2	NO_3	NH_3	Total Nitrogen	PO_4 Ortho	PO_4 Total	CODs	
1		1.0	1.7		38.6	40.4		430	100	6.7	6.4	7.2	6.0	78	92			#1	.1	11	47.8	24			102	
2		0.9	1.6		38.5	39.3		430	100	7.0	6.2	8.0	6.8	78	90			#3							600	
3		1.1	1.3		40.8	41.5		480	80	6.8	4.9	8.6	6.7	78	87											
4		1.2	1.3		40.8	41.5		480	90	6.8	4.9	8.6	7.7	78	86	830	287									
5		1.2	1.3		40.8	41.5		480	80	6.8	4.9	8.6	6.9	77	84											
6		1.0	1.5		39.1	39.6		495	100	6.8	5.0	7.8	7.1	77	82											
7		1.0	1.6		38.1	52.5		445	100	6.8	4.9	8.2	7.1	77	81											
8		1.0	1.7		39.1	39.1		450	100	6.9	5.1	8.0	7.2	77	80			#1			5.6				840	
9		1.0	1.6		38.9	40.3		510	80	6.9	5.1	8.3	8.0	77	79			#3							2806	
10		1.0	1.4		38.6	41.1		490	100	6.8	5.1	8.2	8.1	77	78	557	250									
11		1.0	1.4		38.6	41.1		490	100	6.8	6.1	8.0	8.0	77	77											
12		1.0	1.4		38.6	41.1		490	100	6.8	6.1	8.6	7.6	76	76											
13		1.0	1.6		39.1	41.7		500	100	6.8	6.1	8.5	8.3	76	76											
14		0.9	1.6		37.3	38.5		520	80	6.8	4.9	8.8	7.7	76	75			#1							5580	
15		0.8	1.5		36.7	38.4		416	80	6.8	6.1	7.8	7.6	76	74			#3							5600	
16		0.5	1.1		38.9	42.8		460	80	6.9	6.1	-	-	77	74											
17		0.6	1.1		40.1	43.7		430	60	7.0	6.1	-	-	82	75	997	83									
18		0.6	1.1		40.1	43.7		430	60	7.0	6.1	-	-	82	74											
19		0.6	1.1		40.1	43.7		430	60	7.0	6.1	-	-	81	74											
20		0.9	1.3		38.9	40.1		450	65	7.0	6.0	8.0	8.4	81	74			#1			7.2				5380	
21		1.3	1.6		37.7	40.0		520	120	6.7	4.9	8.4	8.6	81	73			#3							5300	
22		1.4	2.1		36.0	39.4		410	66	6.6	6.0	-	-	81	73											
23		1.4	1.7		36.2	40.4		510	110	6.6	5.1	7.7	7.0	81	73											
24		-	-		-	-		-	-	-	-	-	-	81	73	1433	53									
25		-	-		-	-		-	-	-	-	-	-	81	73											
26		-	-		-	-		-	-	-	-	7.6	7.5	81	74			#1					25.0	25.0	3730	
27		-	-		-	-		-	-	-	-	-	-	81	74			#3							6900	
28		0.9	1.5		32.7	39.9		420	100	6.5	5.1	7.6	7.6	81	74											
29		-	-		-	-		-	-	-	-	-	-	82	75											
30		[illegible]	2.2		62.8	39.6		400	50	6.2	4.7	9.2	9.2	82	75											
31																										
32																										
AVE.																										

REPORT OF OPERATION ON FEDERAL GRANT

CITY OF HAMILTON, OHIO
WASTEWATER TREATMENT PLANT
MONTH OF May 1970

Date	TOTAL SOLIDS			VOLATILE SOLIDS			ALKALINITY			pH		DOs		TEMP.		BODs		#	NUTRIENTS											
	Raw	Dir. #1	Dir. #3	Raw	Dir. #1	Dir. #3	Raw	Dir. #1	Dir. #3	Dir. #1	Dir. #3	Dir. #1	Dir. #3	Dir. #1	Dir. #3	Dir. #1	Dir. #3	Digester	NO_2	NO_3	NH_3	Total Nitrogen	PO_4 Ortho	PO_4 Total	CODs	Flow					
1		0.7	1.1		36.9	42.5		170	70	6.1	4.8	7.9	8.0	82	76															
2		0.7	1.1		36.9	42.5		170	70	6.1	4.8	7.9	8.0	82	76															
3		0.7	1.1		36.9	42.5		170	70	6.1	4.8	7.9	8.0	82	76	300	247													
4		0.9	1.4		36.1	40.0				6.1	4.8	8.0	8.0	81	74															
5		0.9	1.4		36.1	40.0				6.1	4.7	8.0	8.0	81	74			#1			4.5	17	8.25	9.75	3	00					
6		0.9	1.5		36.8	41.3				6.0	4.7	7.6	7.8	81	73			#3							6	00					
7		0.9	1.5		36.8	41.3				6.0	4.7	7.6	7.8	81	72			Sludge			48	468			0	216					
8		0.9	1.2		80.9	41.1				6.3	4.9	7.7	8.9	81	72															
9		0.9	1.2		80.9	41.1				6.3	4.9	7.7	8.8	81	73															
10		0.9	1.2		80.9	41.1				6.3	4.9	7.7	8.8	81	73															
11		1.0	1.2		64.9	60.1				6.1	5.0	7.7	8.1	81	74															
12		1.0	1.2		64.9	60.1				6.1	5.0	7.7	8.1	82	74			#1			4.2	16	7.50	7.50	3	00					
13		0.9	1.5		37.3	40.5				6.1	4.8	7.5	8.0	82	74	567	180	#3							6	00					
14		0.9	1.5		37.3	40.5				6.1	4.3	7.5	8.0	82	74			Sludge			48.7	48.2	4.35		0	212					
15		0.5	0.7		35.7	42.6				6.3	5.1	8.4	8.2	82	74															
16		0.5	0.7		35.7	42.6				6.3	5.1	8.5	8.8	82	74															
17		0.5	0.7		35.7	42.6				6.3	5.1	8.6	8.8	82	73															
18		0.9	1.3		36.4	40.6				6.4	4.8	7.5	7.9	81	73															
19		0.9	1.3		36.4	40.6				6.4	4.8	7.5	7.9	81	72			#1	0.1	1	185.6	156	80	180	3	00					
20		0.8	1.1		36.5	41.0				6.3	4.8	7.4	7.6	82	73	213	69	#3							6	00					
21		0.8	1.1		36.5	41.0				6.3	4.8	7.4	7.6	82	74			Sludge				47.4				0.25					
22		0.9	1.1		36.4	42.3				6.1	4.6	-	-	82	74															
23		0.9	1.1		36.4	42.3				6.1	4.6	-	-	82	75															
24		0.9	1.1		36.4	42.3				6.1	4.6	5.4	7.6	83	76															
25		0.8	1.1		35.1	39.1				6.1	4.6	7.2	6.4	84	76	253	77													
26		0.8	1.1		35.1	39.1				6.1	4.6	7.2	6.4	83	76															
27		-	-		-	-				-	-	-	-	83	76			#1	0.1	1	12	4.5	15	2.50	5.50	3	216			
28		0.3	1.1		37.8	40.9				6.6	4.6	7.4	7.6	83	76			#3				48.0	85			3	220			
29		-	-		-	-				-	-	-	-	83	76			Sludge								3.24	3.			
30																														
31																														
TOT.																														
AVE.																														

Conseer, Townsend and Associates
CONSULTING ENGINEERS
360 EAST GRAND AVENUE – CHICAGO, ILLINOIS 60611
(312) 337-6300

FOUNDED IN 1910

March 30, 1970

Mr. Harold W. Augenstein, Project Director
Wastewater Treatment Plant
City of Hamilton
2451 River Road
Hamilton, Ohio 45011

Re: FWPCA Grant No. 17070 DIW
Aerobic Digester Heating

Dear Harold:

Referring to our meeting with the Taft Center FWPCA personnel at Hamilton on March 18, 1970, it seems evident that some positive evaluation of heating conditions is required, both for present control of experimental procedures and for the future report. Summarizing that meeting, I believe that we were all in accord with the premise that air application to the enclosed aerobic digesters could not conceivably account for the temperatures in the tanks, nor for the continuing rate of increase, although it did account for some reasonably significant part of tank temperature. We further agreed that heat or energy produced by combustion and biological action in reduction of volatiles must constitute a major source in the absence of any other heat generating means.

Following this meeting, I investigated the literature in an attempt to find some specific information on actual heat generation by bacterial action. It was found that, although heat and energy from such sources are recognized, actual means for calculation are not established, probably because means for accurate determination have not been developed. It did seem, however, that we might have some unique possibilities in this regard, due to accurately determined and recorded temperatures, flows, air application, volume and characteristics of materials, volatile reductions, etc. Proceeding on this premise, the attached calculations were made, briefly described as follows.

Heat required to satisfy the determined conditions was computed using standard procedures and values, as normally used for covered and heated anaerobic digesters, identical to these tanks as converted to covered aerobic digesters. Heat applied by means of compressed air at known volume and temperature is calculated from standard formulae for determination of exchange into liquid of known temperature. Heat generated by volatile reduction is based on anaerobic methane production, although this is aerobic volatile reduction, and probably constitutes the most interesting phase of this analysis. As expressed in the calculations, however, it is the opinion that equivalent heat would be produced in either process, the only differentiation being in the release of the heat generated. The heat balance resultant

from this method of calculation and evaluation appears to be remarkably accurate, as compared to the existent condition.

As a further check of the practicality of this theory, the heat balance of the No. 3 digester has been similarly computed on Sheet 2 of the calculations. This tank is completely stable, with no further volatile reduction evident nor probably possible; therefore, the only heat source which can be considered is from the compressed air applied to the tank. The balance computed and shown under such conditions is even closer than in the active tank, inasmuch as the heat demand to maintain the stabilized tank temperature is almost identical to heat input through compressed air application. The validity of the theory would therefore appear to be indisputably established by these comparative analyses.

The basic factors in these calculations have been thoroughly discussed with the heating and ventilating section of our Mechanical Engineering Department, and are in accord with their expressed opinions and advices. There have been further discussions on cooling of tank contents by means of outside air application to the tank zone between the liquid and the floating cover. In an open tank (to atmosphere), such as a conventional aeration or aerobic digester, evaporative cooling can be depended on for extensive heat dissipation. In the covered tanks, however, little if anything would be accomplished, inasmuch as evaporation would occur principally after exhausting from the enclosed space. Air cooling would, therefore, be limited to the amount of air applied to this zone, and to the temperature differential between tank contents and combined air composed of outside air and air discharged through the liquid. Assuming tank temperature at 90°, the exhaust air from the liquid would be at similar temperature. If the outside air temperature was also at 90°, then the combined air and liquid would all be at the same temperature and no cooling would result. It is therefore the opinion that cooling proclivities by this means would be highly variable, and only seasonally effective to any degree. Control of temperature by this means, if not impossible, would be extremely doubtful even under most optimum climatic conditions.

This discussion is primarily in the interests of analysis and evaluation of factors developing during initial phases of operation, or institution of operation, of this experimental project. Recommendations for any specific course of action to be taken to resolve the present problems are necessarily a matter of further discussion between all interested parties. As a preliminary comment, however, it appears that liquid to liquid exchange might be the only feasible solution. The existing heat exchangers, using plant effluent for the exchange media, could probably be utilized for this purpose. Whether the expense involved in revisions and operation is warranted is a matter for decision after discussion.

Two additional copies of this letter with calculations are enclosed for further distribution, if you desire.

Very truly yours,

CONSOER, TOWNSEND & ASSOCIATES

By Carl D. Wright
Carl D. Wright, P.E.

CDW:eh
Enc.

CONSOER TOWNSEND AND ASSOCIATES CHICAGO

PROJECT HAMILTON, OHIO NO. 1 OF 2
SUBJECT AEROBIC DIGESTION DESIGNED CDW DATE 3/2
Heat Calculations CHECKED DATE

BASIC DATA

Digester No.1 (control tank)..... 86700 cu ft = 650000 gal
Raw sludge feed..... 15000 gpd
Digester temperature..... 85°F
Continuing temp. rise..... 2°F/day
Air applied..... 3500 cfm
Air discharge temperature.... 120°F

HEATING

Raw Sludge

Tank temp..... 85°
Sludge temp..... 70°
Raise..... 15°

Heat reqd. = $\frac{15000 \text{ gal.} \times 8.34 \text{ lbs} \times 15°}{24 \text{ hrs}}$ = 78250 Btu/hr

Radiation Loss

Rate.... 1° loss/day/lb contents (winter)

Loss = $\frac{650000 \text{ gal} \times 8.34 \text{ lbs} \times 1°}{24 \text{ hrs}}$ = 226000 Btu/hr

Continuing Rise

2°/day average

Heat reqd. = $\frac{650000 \text{ gal} \times 8.34 \text{ lbs} \times 2°}{24 \text{ hrs}}$ = 452000 Btu/hr

Total demand to satisfy existing conditions = 756250 Btu/hr

HEAT SOURCE

Air

Specific heat....0.241
Wt./cu ft.....0.075
Btu/hr/cu ft/° = 0.241 x 0.075 x 60 min = 1.085
Temp. input air.... 120°
Temp. exhaust air... 85° (same as tank)
Temp. drop..... 35°
Heat applied = 1.085 x 35° x 3500 cfm = 133000 Btu/hr
Demand unsatisfied by air transfer = 623250 Btu/hr

Volatile Reduction

Raw sludge...SS @ 5% = 6250 lbs / VSS @ 70% = 4375 lbs
VSS destroyed (computed). 2350 lbs 2350 lbs
Digested sludge.....SS = 3900 lbs VSS = 2025 lbs (52%
Gas produced @ 12 cu ft/lb VSS destroyed = 12 x 2350 = 28200 cu ft

$\frac{28200 \text{ cu ft}}{24 \text{ hrs}}$ x 600 Btu value = 705000 Btu/hr

Balances unsatisfied demand within 13% + tolerance

CONSOER TOWNSEND AND ASSOCIATES CHICAGO

PROJECT HAMILTON, OHIO NO. 2 OF .

SUBJECT AEROBIC DIGESTION DESIGNED LDW DATE 3/2

Heat Calculations CHECKED DATE

Calculation for heat produced by volatile reduction is based on anaerobic digestion, in which heat produced, released as CH_4, is available by burning the methane thus produced. Aerobic processes release principally CO_2, having no heat value, but it must be assumed that the biological breakdown is equally productive of heat. This is discussed in the following reference:

Microbiology for Sanitary Engineers.

By: Ross E. McKinney, Civil Engineering Dept., University of Kansas.

Published by: McGraw-Hill, 1962.

Chapter 9 - Energy, pages 97-111.

It is therefore theorized, and substantiated by the carefully recorded data and analyses of full scale operation, that, regardless of process involved, volatile reduction produces an identical heat value. In the case of aerobic processes this heat is released directly to the tank contents.

CHECK DATA

Digester No. 3 (Wild tank)	86700 cu ft = 650000 gal
Raw sludge feed	None
Digester temperature	50° F
Continuing temp. rise	None
Air applied	2000 cfm
Air discharge temperature	95 °F

Raw Sludge Heating

None 0 Btu/hr

Radiation Loss

Rate .... 0.5° loss/day/lb contents @ reduced temp. (50°)

Loss = $\frac{650000 \text{ gal} \times 8.34 \text{ lbs} \times .5}{24}$ = 113000 Btu/hr

Total demand ..... 113000 Btu/hr

Source

(Air only - no volatile reduction)

Temp. input air .... 100°

Temp. exhaust air .... 50° (same as tank)

Temp. drop ..... 50°

Heat applied = 1.085 × 50° × 2000 cfm = 108500 Btu/hr

Approx. same as demand with in 4% - tolerance

CITY OF HAMILTON, OHIO

phone (513) 895-7401
municipal building
monument at high
hamilton, ohio 45011

Wastewater Treatment Plant
2451 River Road

May 8, 1970

Mr. Robert L. Feder, Project Officer
F.W.P.C.A. - Dept. of Interior
Robert A. Taft San. Eng. Center
4676 Columbia Parkway
Cincinnati, Ohio 45226

Re: Grant No. 17070 DIW
Summary of Activities To-date
and Recommendations

Dear Mr. Feder:

On June 28, 1968, the City of Hamilton, Ohio, received a Research and Development Grant from the Federal Water Pollution Control Administration, Department of Interior, in the amount of $242,804. on a total estimated project cost of $322,406 for the "Conversion of Existing Anaerobic Digesters to Heated Aerobic Digesters -- Full Plant Scale."

Plans were prepared, bids were received and a contract was entered into with The Antenen Construction Co. on Nov. 5, 1968, to revamp Nos. 1 and 3 digesters from anaerobic to aerobic operation. The contract price was $134,000. The low bid was $4000 over the estimated cost on construction. A request was made to the Federal Water Pollution Control Administration to transfer $4000 from the Contingency Fund to the Construction Fund and the request was granted.

According to the original schedule, the construction was to be completed in six months or by April 1969. Due to the delay in receiving the aeration equipment and getting the contractor on the job, the project was not completed until Sept. 1969. The blowers were officially tested on Sept. 25, 1969, and their performance was satisfactory.

In view of the long delay in completion of the construction work, it was obvious that the project could not be completed by June 1970. The City of Hamilton asked for an extension of time and on Oct. 22, 1969, an extension of eight months was granted. This extended the completion date of the project to Feb. 1, 1971.

On Oct. 7 and 13, 1969, Nos. 3 and 1 digesters were filled with plant

secondary effluent. The digesters were aerated for several days to obtain stability and D.O. residual. On Oct. 18, 1969, we started feeding No. 3 digester with sludge from the primary settling tanks at a rate of 100 GPM for a total of 11,000 gal/shift or 33,000 GPD. The air flow was maintained at 3500 cfm. We stopped feeding sludge to No. 3 digester on Oct. 20 due to the absence of D.O. residual. The air flow was increased to 6000 cfm and on Oct. 22 analysis showed a D. O. residual of 3.2 MG/L. On Oct. 24, we resumed sludge feed to No. 3 digester at original rate (33,000 GPD). The D.O. on this date was 1.2 MG/L with no change in air flow rate. By Oct. 25, the suspended solids in No. 3 digester had built up to 11,436 MG/L.

On Oct. 25 we started feeding No. 1 digester at the rate of 33,000 GPD. The air flow was maintained around 3000 cfm to this digester. The sludge feed to each digester (1 & 3) was continued at the rate of 33,000 G/D, maintaining a D.O. residual of 1.0 MG/L to 3.0 MG/L.

We installed thermometers and pressure gauges on blower discharge lines with a flow of 2750 cfm of air to each digester. The air pressure was approximately 6#/sq.in. and the air temperature was 120°F. By Oct. 29, the suspended solids in No. 1 digester was 10,108 MG/L and 10,464 MG/L in No. 3 digester.

During this period, the partially oxidized sludge from Nos. 1 and 3 digesters was decanted to No. 4 digester being used as a holding tank. On Oct. 31 we started pumping sludge from No. 4 digester to the vacuum filter. The most successful dosage of chemicals was 1% ferric chloride and 5% lime by volume. (The CaO of the lime is 72%).

Nov. 3, 1969, was the date established as the starting date of Phase 1 of the original schedule. Both odor and temperature problems began to develop in both digesters. Phase 1 sludge rate to No. 1 digester, the digester designated for pilot study, was to be 33,000 gallons/day or a residence time of 20 days. The air flow was to be maintained around 2000 cfm to No. 1 digester at this sludge rate, but was found to be insufficient in maintaining a D.O. residual.

We increased the air flow to No. 1 digester to 6000 cfm or 69 cu.ft./1000 cu.ft. of digester capacity. The D.O. residual increased slightly; but we were unable to control the sludge temperature. The highest air temperature to the digester was 135°F and the temperature of the sludge increased to 97°F. The digester covers interfered with surface cooling resulting in very little heat dissipation. The sludge temperature during this phase was to be maintained around 55°F to 65°F.

With the increased air flow and sludge temperatures, undesirable odors began to emanate to the South Hamilton residential area and Miami University Hamilton Campus. Many masking materials were used to minimize the odor, but they had very little effect.

The situation as explained above occurred also in No. 3 digester.

During the period from Nov. 3, 1969, to Nov. 14, 1969, the sludge analyses in the digesters varied considerably: pH--5.2 to 7.0; alkalinity--0 to 800 MG/L; D.O.--0 to 3.0 MG/L; and total solids--1.0 to 3.5%.

During this period another odor problem developed in No. 4 digester (the holding tank) due to septic conditions of the sludge. We were unable to withdraw the sludge rapidly enough from this digester to avoid this situation.

On Nov. 14, on the advice of Dr. Ron Lewis, Mr. Robert Feder, Mr. Carl Wright and plant personnel, it was decided to stop all sludge flow to Nos. 1 and 3 digesters, which would permit cleaning all septic material from No. 4 digester.

On Nov. 19, Dr. Lewis, Mr. Wright, Mr. Feder and plant personnel met to discuss and determine immediate digester operation procedure. The following items were agreed upon:--

(1) Finish cleaning No. 4 digester and leave out of service.

(2) Continue to aerate Nos. 1 & 3 digesters at a reduced rate (4000 cfm or less if we can maintain a D.O. residual). Do not add sludge. Maintain stable conditions by checking pH, D.O. and alkalinity.

(3) Determine if all odor is emanating from No. 4 digester.

(4) If all odor is coming from No. 4 digester, begin feeding Nos. 1 and 3 digesters at a reduced rate of 3000 GPD with feed rate increase of 1500 GPD every 3 to 4 days if conditions warrant.

We finished cleaning No. 4 digester by Nov. 28 and found considerable odors still emanating from Nos. 1 and 3 digesters. Foaming of No. 1 digester required a reduction of air flow to 2600 cfm to bring it under control. Air flow to No. 3 digester was maintained at 3200 cfm. Conditions on Nov. 28, 1969, in Nos. 1 and 3 digesters were as follows:--

	No. 1 Digester	No. 2 Digester	Raw Sludge
pH	7.0	7.9	6.2
Alkalinity	310	1050	950
D.O.	3.1	.98	0.0
Total Solids	3.1%	3.5%	5.2%
Volatile Solids	60%	62.5%	68%
Sludge Temperature	106°F	103°F	

A comparison of the volatile solids would indicate that very little digestion had taken place.

A meeting was held at the Hamilton Wastewater Treatment Plant on Dec. 16, 1969, to discuss operational problems and make recommendations for future procedures. Those

present were Mr. Carl Wright, Consoer-Townsend; Mr. Gene Harris, F.W.P.C.A.; Dr.Ron Lewis, Taft Center; Mr. Ned Thompson, Walker Process; Mr. John Engle, Mr. Harold Augenstein, Mr. Thomas Harrell and Mr. Mike Wheeler, City of Hamilton.

The entire process pertaining to operation procedure and analyses were discussed since the first phase of the digester project began on Oct. 31, 1969. Many possibilities were presented pertaining to operating difficulties. It was the general opinion that the sludge feed to the digesters should have been controlled at a much lower rate at the start-up to allow more time for stability to be established. The original schedule called for a residence time of 10 days in the digesters. This would be equivalent to a sludge flow rate of 65,000 GPD. The original sludge flow rate was reduced to a 20-day residence time or 33,000 GPD. There was no reason to believe that stability could not be established at this rate in view of start-up procedure in our aeration tanks in the activated sludge process. One point that was overlooked was the great volume of air required to maintain a D.O. residual and the inability to control the temperature of the sludge resulting in a steady changing environment for the propogation of definite types of bacteria.

After several hours of discussion, those present agreed upon the following procedures for rescheduling start-up of phase one of the Research & Development project:

(1) Resume feeding of No. 1 digester on Jan. 3, 1970.

(2) Make complete analyses of digester sludge in advance of Jan. 3, 1970.

(3) Sludge feed to No. 1 digester will be at the rate of 3000 GPD. When stability has been established, the feed rate should be increased 1500 GPD every 7 days.

(4) No. 4 digester is not to be used as a holding tank during this start-up period; but the overflow from No. 1 digester will be permitted to flow by gravity back to the wet well and be mixed with raw sewage thus avoiding septicity of the waste sludge.

(5) Continue to aerate No. 1 digester at an air flow rate of 1700 cfm or maintain a residual of not less than 2.0 MG/L D.O.

(6) Permit air temperature to drop correspondingly with decreased air flow. No attempt will be made to maintain a definite temperature of the sludge.

(7) Continue to aerate No. 3 digester sludge with air flow of 2000 cfm. Analyses will also be made on sludge in this digester as in No. 1 digester.

(8) BOD probe is acceptable in checking BOD analyses instead of the Winkler method.

(9) Mr. Robert Booth, coordinator of Analytical Quality Control, F.W.P.C.A., will consult with plant personnel regarding analytical procedures.

Mr. Robert Booth presented plant personnel with a new set of standards to follow in our analytical work. The title of the manual is "FWPCA Methods for Chemical Analysis in Water & Wastes, Nov. 1969." It would have been of considerable advantage to laboratory

personnel if this manual had been available earlier in the grant when they were attempting to standardize analytical procedures.

As we continued to stabilize conditions in Nos. 1 and 3 digesters, we were able to reduce the air flow to 2000 cfm. Analyses of sludge and digester conditions on Dec. 29, 1969, were as follows:--

	No. 1 Digester	No. 2 Digester
pH	6.9	6.4
Alkalinity	705	650
BOD	463	135
Total Solids	1.4%	1.7%
D.O.	8.3	9.3
Volatile Solids	41.3%	31.9%
Sludge Temperature	67.5°F	70°F

Sickness of lab personnel delayed the start of sludge feeding from Jan. 3, 1970, to Jan. 12, 1970. The sludge feed rate was 3000 GPD and air flow rate 2000 cfm at start-up. The sludge flow was increased 1,500 GPD on a weekly basis for the remainder of January. The D.O. residual was maintained near saturation with no increase in air flow. Analyses of the sludge Jan. 31, 1970, showed a reduction of 66.5% volatile in No. 1 digester. We had hoped that this would establish a guide line for the remainder of the project.

For the past five weeks, conditions in No. 1 digester looked very good; so on Feb. 7, 1970, it was decided to increase the weekly sludge feed increment from 1500 GPD to 3000 GPD. The sludge feed rate to No. 1 digester at this time was 10,500 GPD. A drop in D.O. residual on Feb. 8, 1970, to 4.0 MG/L made it necessary to increase the air flow to No. 1 digester to 2500 cfm. By Feb. 9, the D.O. residual was back to 8.2 MG/L.

On Feb. 14, the sludge flow was again increased by 3000 GPD to No. 1 digester to a total flow of 13,500 GPD. The D.O. dropped from 7.7 MG/L to 6.1 MG/L. After increasing the air flow from 2500 cfm to 3000 cfm, stability was again restored.

To avoid the shock from the 3000 GPD weekly increase, it was decided on FEb. 18 to change the weekly increase of sludge flow to No. 1 digester from 3000 GPD per week to 450 GPD per day. This change in schedule took place on Feb. 21.

Stability was maintained until Feb. 25 when the D.O. residual dropped to 1.3 MG/L. The sludge flow at this point was 15,600 GPD. Sludge flow to No. 1 digester was stopped and the air flow was increased to 3500 cfm on Feb. 27. There was no increase in D.O.

residual by Feb. 28, but the sludge temperature in the digester had increased to 86°F. A slight odor of the sludge again appeared similar to the condition at the beginning of the project.

The air flow was maintained at 3500 cfm until March 4. After we stopped the sludge flow to No. 1 digester, the temperature continued to rise and the D.O. residual continued to drop. On March 4, the sludge temperature was 93°F and the D.O. residual was 0.4 MG/L. The sludge temperature continued to rise (100°F) so we decreased the air flow to 2000 cfm. The odor from the digester was becoming quite undesirable. To avoid public criticism, we started pumping secondary plant effluent to No. 1 digester in order to lower the temperature and to decrease the rate of biological activity.

We continued to elutriate the sludge in No. 1 digester until March 13. The temperature by this time was down to 87°F and the D.O. residual was 2.0 MG/L. Also the odor had begun to subside.

On March 18, a meeting was held at the Wastewater Treatment Plant to determine the procedure we should follow to control No. 1 digester temperature. Those present at the meeting were Mr. Carl Wright, Mr. Gene Harris, Dr. Ron Lewis, Mr. Harold Augenstein and Mr. Thomas Harrell. It was proposed that a 5000 cfm fan be placed over the 30" opening in No. 1 digester cover to obtain surface cooling of the sludge. The fan operated until March 29 with only a minimal drop in temperature. The sludge temperature on this day was 78°F and the D.O. residual was 8.8 MG/L.

On April 3, we received a report from Mr. Carl Wright of Consoer-Townsend & Assoc., pertaining to heat calculations that he and other members of the Consoer-Townsend staff had worked out in regards to No. 1 digester. The report showed the inadequacy of the fan method of cooling and proposed liquid-to-liquid cooling to control the temperature of the sludge. The fan was shut down on March 30. No attempt was made to start feeding No. 1 digester again, but the air flow has been maintained at 2000 cfm as of this date.

After considerable difficulty, we were able to schedule a meeting on April 27, 1970, at the Wastewater Treatment Plant with the following personnel present: Mr. John Engle, Director of Utilities of the City of Hamilton; Mr. Carl Wright, Consoer-Townsend & Assoc.; Mr. Robert Feder, Dr. Joseph Farrell and Mr. James Smith, F.W.P.C.A.; Mr. Harold Augenstein, Mr. Thomas Harrell and Mr. Mike Wheeler, City of Hamilton. The discussion covered all aspects of the grant project from the beginning to the present. Various methods of liquid cooling were presented but all were quite costly. We were unable to justify the cost of this type of installation since we could not be assured it would solve our problem. The City of Hamilton is unwilling to invest more money into a project

that in all probability will not be used. Since the grant has been received, there has been a proposal from U.S. Plywood-Champion Papers, Hamilton, Ohio, and the Ohio Water Development Authority, Columbus, Ohio, that the City of Hamilton consider a complex that will treat jointly the wastewater from the City of Hamilton and U. S. Plywood-Champion Papers. It would appear that this project will become a reality and if it does there would be no need for the conversion of the digesters to aerobic operation. The additional organic matter in the sludge would be needed for incineration. Any future benefits or knowledge gained from the continuation of the conversion project would be strictly academic benefitting the Federal Water Quality Administration as a whole. There is approximately $100,000 left in the original grant of $241,804. It was determined by those present at the meeting on April 27, 1970, that there were insufficient funds remaining to make the necessary equipment changes and complete the project as originally scheduled.

In a report written by Prof. John F. Andrews, Dept. of Environmental Systems Engineering, Clemson University, on "An Aerobic Thermophilic Process for the Treatment of Wastes," he describes a pilot study that he conducted that appeared to have a great deal of potential for treatment of organic solids. The thermophilic range in which this study was conducted was between 110°F to 150°F. Mention is made in this report concerning the inablity to maintain sufficient oxygen at this temperature. The solubility of air in water at this temperature decreases rapidly and makes it quite difficult to avoid septic conditions and the production of undesirable odors. The experience we encountered with odors in past months makes it undesirable to experiment in the thermophilic range on plant scale.

In view of the many described difficulties that we have encountered during the study and with minimum value to be gained by the City in our planned future treatment expansion program, it is the recommendation of the officials of the City of Hamilton that the digester conversion project under the Research & Development Grant No. 17070 DIW be terminated.

We hope you will consider this request and act upon it with favor.

Sincerely yours,

H. W. Augenstein

Harold W. Augenstein,
Project Director